that regulatory capital recovery has been wholly inadequate. In this respect, the Hatfield Model (originally funded by MCI) contradicts depreciation testimony filed by MCI.[1] The same result is obtained by J.R. Norsworthy in a study filed by AT&T in the LEC price-cap docket. The Norsworthy model also implies that LEC capital recovery has been wholly inadequate.

It is ironic that studies funded by MCI and AT&T both imply a much more serious capital-recovery problem than the LECs' conservative estimates.

II. Background

A. Regulatory Depreciation Methods

Regulatory depreciation methods are invariably straight-line. For new investment, annual depreciation expense is the difference between the plant's original cost and its future net salvage value divided by the plant's depreciation life.[2] The FCC prescribes both the life and net future salvage value.

Depreciation expense continues at the annual rate, so determined, until a formal regulatory decision to change the rates. Interstate depreciation rates are changed periodically, following reviews of depreciation data.[3] Most state commissions no longer use the same depreciation rates for intrastate as the FCC does for interstate (within the state).

After a periodic review, depreciation rates for embedded plant (as well as new investment) may be changed on a forward-going basis. New annual depreciation expense for embedded plant is the difference between net plant and net future salvage value divided by the remaining life of the plant. The net value of plant is original cost less depreciation charges to date.

B. Regulatory Policy

To achieve low prices, regulators have often sought to set the depreciation life of plant equal to its physical life, with limited adjustments for the impact of obsolescence. For much of LEC plant,

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[1] *See* Kenneth C. Baseman and Harold Van Gieson, *Depreciation Policy in the Telecommunications Industry: Implications for Cost Recovery by the Local Exchange Carriers,* prepared on behalf of MCI Telecommunications Corporation (MICRA, December 1995).

[2] Net future salvage value is sometimes negative; it is often significantly negative for outside plant. Hence, the difference between original cost and (negative) net future salvage value may exceed original cost.

[3] Periodic reviews used to be triennial, but they may now occur more or less frequently.

the resulting depreciation life greatly exceeds "economic life"; *i.e.*, the period when the plant has substantial value in use. Plant should be fully, or almost fully, depreciated by the end of its economic life. Regulators generally do not take account of economic value in setting depreciation rates.

The physical life of telecommunications plant is often quite long. Since telecommunications plays a vital role in both everyday life and emergencies, telecommunications systems must be highly reliable. Reliability in traditional telecommunications networks is created, in part, by building cables that resist water intrusion, putting conduits well below ground, using connection technologies that resist failures from oxidation or vibration — in other words by building solid and strongly constructed system elements. A natural characteristic of such highly reliable equipment is physical longevity (even under difficult circumstances).

At the same time, telecommunications plant is subject to rapid innovation. Plant may become obsolete and reach the end of its economic life long before its physical life ends. Furthermore, straight-line depreciation, even over economic lifetimes, may not fully reflect decline in economic value (until the plant is fully depreciated).[4] Economic depreciation is often more rapid than straight-line in the early years.

Businesses and consumers are familiar with this phenomenon in other areas. In back rooms of businesses around the world, 386 and 486 computers that are only a few years old can be found idle. Those computers still work well, but now serve only as backups or spares. More up-to-date models are sufficiently more productive that they justify putting two- and three-year-old computers out to pasture.

Capital recovery means paying back the long-term investments that LECs made to provide the public with telephone service. Much is said about the "regulatory compact" under which most of the investment in today's local telephone networks was undertaken. Simply stated, telephone-company investors made sizable investments in order to build telephone networks. They were

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[4] The FCC explicitly acknowledges this latter point. *See* FCC, *In the Matter of Access Charge Reform* (CC Docket No. 96-262), *Price Cap Performance Review for Local Exchange Carriers* (CC Docket No. 94-1), *Transport Rate Structure and Pricing* (CC Docket No. 91-213), *Usage of the Public Switched Network by Information Service and Internet Access Providers*, (CC Docket No. 96-263), Notice of Proposed Rulemaking, Third Report and Order, and Notice of Inquiry, ¶ 253, adopted December 23, 1996, released December 24, 1996.

willing to limit their return on those investments to a "fair rate of return."[5] In exchange, they expected a reasonable opportunity to earn that fair rate of return until their capital was eventually returned to them through charges for depreciation expense.[6] In the past, regulators have tightly controlled depreciation practices. LECs were never permitted to take any depreciation charges that were not specifically approved by regulators. Hence, LECs have had no opportunity to date to recover capital beyond that permitted by regulators. In order to honor explicit and implicit commitments to investors, regulators must provide a reasonable opportunity in the future for LECs to recover (and earn a fair return on) the remaining embedded capital.

In a monopoly environment, regulators can always provide the LEC an opportunity to recover capital, even if over more years than are appropriate; *e.g.*, by approving sufficiently high prices.[7] The LEC is made whole, even if it recovers the capital later; so long as it can earn a fair return on unrecovered capital in the meantime.

As markets become more competitive, recovery of capital becomes more problematic. In particular, once a market is *effectively* competitive, a LEC will be able to recover (and earn a return on) only the economic value of the capital. It will not be able to recover capital that exceeds economic value — even if the capital is in the regulatory rate base. At that time, it will be too late for regulators to solve the problem by granting price increases on competitive services, because prices will be limited by market forces.

To honor explicit and implicit commitments to investors, regulators need to give LECs the opportunity to recover capital that exceeds economic value *before* markets become effectively

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[5] In this paper, we use the term "fair rate of return" in the legal sense, as defined by court decisions. For example, *see* Bluefield Water Works & Improvement Co. v. Public Service Commission of West Virginia (262 U.S. 679, 1923); *Federal Power Commission v. Hope Natural Gas Company* (320 U.S. 391, 1944); *Permian Basin Rate Cases,* 390 U.S. 747 (1968) and *Federal Power Commission v. Memphis Light, Gas & Water Division,* 411 U.S. 458 (1973). As defined in these decisions, fair rate of return means a return sufficient to maintain financial integrity, attract capital, and earn a return commensurate with unregulated enterprises having comparable risk.

[6] The regulatory compact is not an unwritten agreement, as is occasionally claimed. It is embodied, in part, in the court decisions cited in the previous footnote.

[7] Under rate-base, rate-of-return regulation, capital recovery directly and explicitly affects prices. Under price caps, the plan should be designed to afford the company the opportunity for adequate capital recovery, as well as a fair return.

competitive. To achieve that goal without rate shock, regulators need to address the depreciation shortfall very soon.

Recent interconnection policies also increase the urgency of addressing the capital-recovery problem. The Communications Act of 1996 (the Act) mandates that interconnection prices be based on costs. State regulators approve interconnection prices and are bound by these terms of the Act, even though they are currently not bound by the stayed FCC rules implementing the Act.[8] LECs cannot recover any part of the depreciation shortfall from interconnection prices if those prices are based on forward-looking costs (as the FCC recommends). Such interconnection pricing also makes it difficult to recover the shortfall from end users. If LECs try to do so, they will be undercut by competitors, using cheap unbundled elements. Consequently, to honor explicit and implicit commitments to investors, regulators need to address the capital-recovery problem *before* competition via unbundled elements becomes widespread.

Unless the capital-recovery problem is addressed, investors cannot be expected to continue investing on the same terms as in the past. At best, investors will demand higher rates of return to compensate for the riskier environment. At worst, they will invest their capital elsewhere in the economy — either the United States or abroad.[9]

III. Quantifying the Depreciation Shortfall

A. LEC Estimates

The price-cap LECs that are fully subject to depreciation regulation estimated their depreciation shortfall.[10] The estimates are the difference between actual depreciation reserves and "theoretical reserves." To calculate theoretical reserve, the LECs first estimated economic lives and net future salvage values for each category of plant. The theoretical reserves are what the reserves *would be* if those lives had been in effect during the entire lifetime of the plant.

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[8] *See Iowa Utilities Board v. FCC*, Case Nos. 96-3321, *et seq.*, Stay Order, October 15, 1996. The stay allows state commissions to deviate from the FCC's pricing rules.

[9] This issue is discussed in more detail in Jeffrey H. Rohlfs and Harry M. Shooshan III, "New Investment and the Regulatory Climate," *Telephony*, May 2, 1994, pp. 56-60.

[10] Ameritech did not provide estimates, but all the other fully-subject price-cap LECs did so.

The estimated theoretical reserves differ from the regulatory reserves for two reasons: In the first place, the estimated economic lives are shorter than regulatory lives. (The disparities between estimated and regulatory net future salvage values are much smaller.) Second, the estimated economic lives are applied throughout the entire past life of the plant. The theoretical-reserve calculation differs from regulatory depreciation revisions, which are prospective only and cannot be retroactive.

The LEC estimates of theoretical reserves are shown in Table 1. The overall difference between theoretical reserves and actual regulatory depreciation reserves is 7.0 percent of gross plant — 54.0 percent versus 47.0 percent. The shortfalls are greatest for copper cable (of all types) and digital electronic switching systems (ESS).

Table 1
LEC Estimates of Depreciation Shortfall
(Percent of Gross Plant)

Reserve Percentage	Regulatory Depreciation Reserves (1)	Theoretical Reserves (2)	Shortfall (2) - (1) (3)
Overall	47.0%	54.0%	7.0%
Digital ESS	35.6	46.5	10.9
Digital Ckt.	51.3	53.8	2.5
Aerial Copper	57.8	69.6	11.8
Aerial Fiber	23.8	27.1	3.3
UG Copper	56.9	75.4	18.5
UG Fiber	27.4	33.0	5.6
Buried Copper	50.5	60.9	10.4
Buried Fiber	25.3	28.6	3.3

Source: Data provided by LECs.

Table 2 shows the estimated depreciation shortfall for each (fully-subject price-cap) LEC. The total estimated shortfall for all these LECs is approximately $18 billion.

Table 2
Estimated End-of-Year 1996
Depreciation Shortfall

Company[1]	Access Lines[2] (1)	Unseparated Depreciation Shortfall ($000) (2)	Interstate Depreciation Shortfall ($000) (3)
Ameritech	19,057,000	NA	NA
Bell Atlantic	19,603,013	$2,673,339	$739,810
BellSouth	21,158,278	2,643,524	579,371
GTE	17,609,027	3,141,801	816,500
NYNEX	17,138,000	668,300	157,600
Pacific Telesis	15,782,000	2,343,679	524,457
SNET	2,030,712	657,300	173,411
Southwestern Bell	16,343,359	1,759,442	462,873
U S West	14,544,666	1,699,419	446,058
Total	143,266,055	$15,586,804	$3,900,080
Total (without Ameritech)	124,209,055	$15,586,804	$3,900,080
Gross-Up Ratio	1.15		
Grossed-Up Results		$17,924,825	$4,485,092

[1] Only FCC-subject price-cap LECs are included.
[2] December 31, 1995 access line data from the USTA 1996 Holding Company Report.

Source: Data provided by LECs.

LECs have already increased depreciation reserves on their financial books in accordance with FASB101. The revisions are intended to give stockholders and bondholders a more accurate view of the value of the companies' plant. The theoretical reserves shown in Table 1 are substantially lower than those on the financial books of the LECs. This finding is consistent with the view that the estimates of the depreciation shortfall in Table 1 are conservatively low.

B. Evaluation of LEC Estimates

The LECs used various procedures to estimate lives and net future salvage values. These procedures naturally involve judgments and forecasts about the future. In this paper, we do not attempt to evaluate the procedures themselves. Rather, we examine whether the results of those procedures — *viz.*, the estimates of theoretical reserves — are themselves reasonable.

How does one evaluate whether a particular level of depreciation reserve is reasonable? We believe that the proper standard is whether the remaining net plant is carried on the books at a level that reflects its actual value in use. Ideally, net plant should be valued so that the incumbent can use that plant and compete with an equally-efficient competitor who uses newly purchased plant. This standard is known as "economic value." The decline in economic value from one year to the next is "economic depreciation."[11]

Valuing net plant at economic value is essential in order for competition to yield efficient outcomes. Competitive battles should go to the more efficient firm. The incumbent should not lose simply because of uneconomic regulatory depreciation practices. If competitive battles are determined on the latter basis, the outcome will be misallocation of resources and loss of productivity for the industry.

Two examples will help clarify the concepts of economic value and economic depreciation:

1. Example of Long Physical Life with Declining Prices

Suppose that an item of plant costs $1 million and lasts 300 years. Suppose further that the cost of new plant falls by 10 percent each year; *i.e.*, the cost to purchase new plant at the end of each year is 90 percent of what it was at the beginning of the year. (Thus, the price sequence is 100, 90, 81, 72.9 . . . .) In order for the regulatory value of net plant to reflect economic value, it must decline by 10 percent each year.

At the end of the first year, an equally-efficient competitor can purchase new plant for $900,000. Consequently, after the first year, the incumbent would be able to compete only if the

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[11] A classic article on economic depreciation is Harold Hotelling, "A General Mathematical Theory of Depreciation," *Journal of the American Statistical Association,* September 1925.

plant had already depreciated to $900,000 by the end of the first year.[12] If depreciation in the first year were less than 10 percent, the incumbent would thereafter need to recover and earn a return on a larger amount of capital than the entrant. Competition would therefore be skewed and would not be efficient. The incumbent would either need to charge higher prices than the entrant, or it would fail to recover its full costs — even though the incumbent is (by assumption) equally as efficient as the competitor.

From an accounting perspective, inadequate depreciation in one year can be compensated by excessive depreciation in later years. However, whenever depreciation is excessive, the incumbent cannot compete with an equally-efficient competitor. Under economic depreciation, declines in plant value are recognized the year in which the decline in value occurs. They are not averaged over some hypothetical lifetime, as in straight-line depreciation.

2. Example of High Maintenance Costs

Suppose that an item of plant costs $10,000. It comes with a one-year warranty. The plant can continue to be used after the first year, but maintenance cost is $10,000 per year.

Under these circumstances, the economic value of the plant after the first year is zero. Thus, the plant should be entirely written off (expensed) in the first year. The plant may, indeed, be retired after the first year. However, the firm may choose, for convenience, to retain the capital for two or three years (or even longer). The firm suffers no cost disadvantage by doing so. However long the firm retains the plant, the plant should be fully depreciated (expensed) in the first year.

With a zero valuation at the end of the first year, the incumbent can compete with an equally-efficient competitor who purchases new plant. The incumbent's maintenance costs would exactly balance the entrant's capital costs.[13] After the first year, the incumbent would compete at a disadvantage if it incurred any costs for depreciation and/or return on capital.

These examples clearly illustrate that economic depreciation may not be closely tied to the life of the plant — even the economic life. In the first example, the economic life of the plant is 300 years; yet, annual economic depreciation is 10 percent of net plant. In the second example, the plant

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[12] Depreciation would actually have to be slightly greater than $100,000 in order also to reflect physical wearing out (over 300 years)

[13] In this simple example, we disregard the fact that capital costs must be paid up-front, while maintenance costs may be incurred throughout the year.

may remain in place for an arbitrary period, yet the plant should be fully depreciated (expensed) in the first year.

C. Forward-Looking Costs

In interconnection pricing, the FCC and many state commissions sharply distinguish forward-looking costs from embedded costs. With regard to capital costs, this distinction probably arises primarily because embedded plant is carried on the regulatory books at far above economic value; *i.e.*, because past regulatory depreciation has been inadequate to reflect the decline in economic value. If regulatory depreciation had been adequate, embedded net plant and the economic value of plant would be approximately the same.[14] Put another way:

> *When interveners or regulators draw sharp distinctions between forward-looking and embedded capital costs, they implicitly acknowledge the seriousness of the capital-recovery problem.*

We believe that interveners who do so should be consistent and not attempt to minimize the capital-recovery problem. We believe that regulators should be consistent and address that problem.

IV. Analysis of Telecommunications Technology and Markets

In this section, we analyze LEC depreciation in light of our knowledge of telecommunications technology and markets. We focus on those types of plant for which the shortfalls are greatest in Table 1; *viz.*, cable and wire, and digital electronic switching systems.

A. Cable and Wire

The biggest disparities between book reserve and theoretical reserve are for copper cable. All categories of copper cable — underground, aerial, and buried — show significant disparities between the regulatory and theoretical reserve. Most copper cable is used for loops; interoffice transmission accounts for much less investment and is now largely fiber. Consequently, our discussion of copper cable focuses on loops.

1. Underground Copper Cable

Underground copper cable is placed in conduits. Such cable is normally used in built-up areas such as major central business districts. Much of the existing underground copper feeder is technologically obsolete. That is, if the system were rebuilt today, it would be replaced with fiber

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14 This issue is discussed in more detail below, with reference to the Hatfield cost model.

and remote subscriber terminals. Similarly, underground distribution plant goes to office buildings that could be served more efficiently with digital fiber connections.

Because underground copper cable is largely obsolete, its economic value is far less than original cost. The economic value is always less than the cost of a fiber-optic system that could perform the same functions. The value may be considerably less if customers demand wideband and broadband services that cannot be economically provided over copper cable. Furthermore, underground copper cable is sometimes removed from service while it is still fully functional in order to make room in the conduit for fiber-optic cables. In economic terms, copper cable may be a liability rather than an asset if it inefficiently occupies scarce conduit space and is expensive to remove.

If conduit space is adequate and demand is growing, fiber-optic cable may be installed parallel to embedded underground copper cable. Since fiber-optic cable has such large capacity, the fiber cable would probably have sufficient capacity to meet total demand. However, by continuing to use the embedded copper cable, the LEC can save some costs. It can install less terminal equipment (lasers, light receivers, multiplexers) on the fiber-optic system. It can also save rearrangement costs by continuing to serve some customers with the embedded copper plant. Consequently, the embedded copper plant retains some economic value. However, the economic value under these circumstances is only a small fraction of the original cost of installing the copper cable.

Ironically, regulatory depreciation of underground copper cable is slower than that of other types of copper cable. The FCC's ordered projection life range is from 25 years to 30 years. It is almost inconceivable that newly-installed underground copper cable will retain significant economic value that long. In reality, underground copper cable often has such a short useful life that it is typically not cost-effective technology for new construction.[15]

2. Aerial and Buried Copper Cable

Aerial and buried copper cable include both feeder and distribution plant. Feeder plant goes from the central office (CO) to some intermediate junction point. Distribution plant goes from there to the premises of the businesses and residences served by the central office.

[15] LECs do, however, have small amounts of underground-copper construction to replace or reinforce small segments of existing systems.

For a newly-installed telecommunications system, fiber-optics would be used for most feeder plant. Hence, embedded copper plant in the feeder system is largely obsolete — the same as underground copper cable. Its economic value is correspondingly low.

Today, copper cable is usually the cost-effective technology for distribution plant. However, it is only a matter of time before copper becomes obsolete, even in this application. The costs of fiber-optic systems continue to decline rapidly. In addition, future customers are likely to demand capabilities that cannot be economically provided over copper cable. Cable companies have already successfully offered broadband access to the Internet. This demand can be expected to grow rapidly, as video applications proliferate on the Net. In addition, using the same broadband facilities to provide telephone service and video entertainment services will ultimately be cost-effective.

These developments will not, of course, occur overnight. However, the FCC's projection lives of aerial and buried copper cable currently range between 20 and 26 years. We judge, on the basis of current trends, that copper cable will be largely obsolete well before the end of this period.

Regulatory depreciation should be set so that plant is almost fully depreciated by the time that it becomes obsolete. Regulators have already failed to achieve this ideal with respect to copper feeder plant. Unless the capital-recovery problem is addressed soon, regulators will also likely fail to achieve this ideal with respect to copper distribution plant.

3. Local Competition

Local competition will also drive down the economic value of copper cable. We can confidently expect that some consumers will move their local service to new, facility-based entrants. The most likely entrants in the residential market are radio-based (cellular/PCS and wireless local loop service providers) and cable companies providing telephony and Internet access over broadband systems. The most likely entrants in the business market are fiber-based alternative carriers operating in the central business districts. Next-generation satellite systems offer another source of possible entrants. Since demand for local services grows more slowly than for long-distance services, competition is likely to grow faster than overall demand. Hence, the growth of competition will reduce the effective customer base served by the copper feeder and distribution plant. Less plant will be needed to serve the customer base and the economic value of the plant will decline. Regulatory depreciation should be changed to make an allowance for this likely decline in economic value.

4. Fiber Cable

In Table 1, the depreciation shortfalls for fiber cable are smaller than for copper. They constitute only a small part of the total shortfall, but they are still significant. Current depreciation rates do not adequately reflect technological improvements in fiber.[16] The shortfall may become serious before long if depreciation rates are not increased.

B. Digital ESS

1. Price Declines

The current generation of CO switching machines is largely comprised of digital ESS — software-controlled digital computer systems with associated special-purpose peripheral equipment. Their basic elements are the same type of integrated-circuit silicon building blocks that make up personal computers and video game consoles. It is widely appreciated that the performance of such integrated circuits has doubled every year for the past three decades.[17] For a variety of reasons, however, the price for new ESS equipment has not uniformly tracked this continuing drop in basic input costs.

Nevertheless, CO switch prices have dropped steadily. One 1994 forecast of the price of a digital switch on a per-line basis for the period 1993 through 1998[18] predicts that switch prices will decline by slightly more than 20 percent over five years, or an annual compound rate of 4.4 percent per year. This forecast implies that a conventional ESS switch declines in value by 4.4 percent just by getting a year older — even if the switch is as good as new (see above example of long physical life with declining prices).

2. Functional Obsolescence

Historically, technical obsolescence has been the primary force driving down the economic values of central office switching systems. CO switches have been obsoleted an entire generation at a time by new technologies that enable entirely new functionality or offer significant efficiency

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16 *See*, for example, George Kotelly, "NFOEC rides a wave of products and papers," *Lightwave,* November 1996, p. 7.

17 In 1965 Gordon E. Moore, founder and now chairman of Intel Corporation, observed that the density of integrated circuits packed onto a typical computer chip tended to double each year. This trend, now called *Moore's Law,* is expected to continue for some time. "This means . . . that if you can afford to put it off until next year, don't buy a computer this year." *New York Times*, July 16, 1996.

18 Northern Business Information, *U.S. Central Office Equipment Market* 1994, Exhibit 3-34 at p. 72.

improvements over previous generations.[19] That is, CO switch technology has been retired in "avalanches," including systems which have been purchased relatively recently.[20] A number of inter-related trends point to the imminence of such an avalanche as regards ESS switches. The advent of local exchange competition plays a role in each of them.

a. CPE-based call control

Most prominent of these trends is the recent upsurge of growth in computing power "on the desktop" and on the customer premises generally. This trend is accelerated by the recently increased focus of computing power on networking and communications. Historically, functionality for controlling how calls are set up, controlled, and torn down has resided in the software of the CO switching system. It is invoked by modest touch-tone equipment on the customer premises. Increasingly, however, the customer's equipment is not a Princess hand set; it is a personal computer or other sophisticated device containing its own integrated circuitry. In such a world, the natural engineering economies are for LEC network nodes to quickly connect data pipes and do little else in the way of call handling functionality. The onion layers of accreted software found in embedded CO switches cannot keep up with the ever-changing functional demands of such powerful customer premises equipment (CPE).

The integrated service digital network (ISDN) is a set of international standards. It has been developed largely through the efforts of well-established telephony operating and manufacturing interests. The goal has been to adapt the embedded base of ESS switches to meet needs of computer users. Unfortunately, ISDN has to date proved cumbersome to implement and difficult to sell to end users. Instead, firms participating in this rapidly advancing area of technology have focused their attention on call control technologies influenced by the Internet. After an initial telephone call is made via touch tones, the public switched telecommunications network (PSTN) becomes a simple pipe. The CPE on either end exchanges sophisticated call control commands, setting up and tearing down sessions, painting screens, passing data through to still other computers, *etc*. All this activity

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19 *See* Frank K. Wolf and W. Chester Fitch, *Depreciation Systems* 71 (Iowa State University Press, 1994) for further discussion of historical obsolescence of CO switching systems.

20 *See* Adrian J. Poitras and Lawrence K. Vanston, *Implications of Technology Change and Competition on the Local Exchange Carriers 4* (Technology Futures, Inc., March 1996) for further discussion of the avalanche model.

occurs over the voice path with no further call control information exchanged with the PSTN's ESS equipment.

In such an environment, new services are developed by gaining access to this stream of commands and by characterizing new commands with new meanings to be exchanged between the CPE and the service provider. New entrants, unencumbered by the rigid software structures of conventional ESS systems will effectively raise the ante of competition by building their networks with state-of-the art equipment capable of injecting itself into these CPE call control conversations. The result will be to obsolete LEC ESS systems.

b. Carrier-based call control

New entrants to the switch manufacturing business — firms such as Excel, Summa Four, Harris Corp. and Redcom Labs — are having a substantial impact. These firms had little to lose by aggressively building nonstandard capabilities. They were especially encouraged by new service providers with interests as described in the preceding section. They developed lean, flexible voice circuit switches which could offer a very high level of control to the computers to which they were connected. By drastically reducing the start-up and operating costs of voice response services, these systems have, in only a few short years, made a profound impact noticed by customers with even the simplest of telephones. For example, most network-based voice mail services depend on such an implementation. In the past few years, these systems have matured in reliability and size and they increasingly offer a serious alternative to the previous generation of CO switching equipment — the digital ESS switch. This development is good for end users. It does, however, reduce the economic value of embedded LEC plant.

c. Data and multimedia traffic

The continuing jump in computing performance and slide in computing prices has generated a huge increase in the demand for high capacity digital communications. It is becoming increasingly apparent that at their most fundamental level the current generation of CO switches is not ideally engineered for current traffic patterns — either for the unique patterns of data and multimedia communications (such as Internet access) or for the increasing mix of data with video and voice. Quite likely, these growing streams of traffic will be diverted away from the embedded base of voice-optimized CO switches to new generations of switches based on Asynchronous Transfer Mode (ATM) or other new technology. As a result, new entrants using all new equipment will maintain significant operational advantages going forward. Digital ESS switches will be rapidly obsoleted.

d. Interconnection and competition

Regardless of the demand for multimedia calls and vertical services over voice calls, plain old telephone service (POTS) will remain a significant factor in overall demand for years to come. Even here, however, rapid declines are likely in the economic value of ESS equipment as the platform for offering service. These declines will be driven by both regulatory interconnection requirements and the effects of competition, itself.

Under the Telecommunications Act of 1996, LECs have a statutory duty to interconnect with competing local exchange carriers. The Act further dictates that LECs unbundle their networks at any technically feasible point and to do so in a nondiscriminatory manner. The embedded base of ESS equipment is optimized to switch relatively brief voice calls in a single carrier environment. In effect, the Act adds an additional layer to this design mission: that each network function be invocable and administrable by any carrier.

> *The changes required in embedded ESS software to implement the Act's interconnection obligations could be orders of magnitude greater than those required to implement Equal Access after Divestiture — a change which, itself, effectively obsoleted a whole generation of switching equipment.*

Regulatory interconnection requirements may also directly obsolete embedded ESS switches. For example, upgrading existing switches to provide database number portability and/or intraLATA presubscription may not be cost-effective. If such requirements are mandated by state and/or federal regulators, LECs may have to change out existing switches much sooner than originally expected.

Competition, itself, will also drive down the economic value of embedded ESS switches. New entrants have no incentive to approach the market according to old, regulatorily defined categories of local, interLATA, basic, enhanced, voice, video, Internet, *etc*. They will address a single, cohesive body of customer needs based on ATM or similar high-speed switches which integrate voice, data, and video traffic. These switches may operate unattended, in darkened rooms, often on a customer's premises. They will have low start-up and fixed costs and will allow both the network operators and their customers unprecedented levels of control over the way traffic is handled and network systems are managed. To remain competitive, established LECs will have little choice but to rapidly adopt the new switching technology themselves. Embedded ESS plant will suffer substantial declines in economic value.

e. Implications for capital recovery

An obvious implication of our discussion of obsolescence is that depreciation lives for digital ESS should be shortened. Prescribed projection lives currently range between 13 and 18 years for the fully-subject price-cap LECs. Newly installed ESS machines will likely be obsolete much sooner than 13 to 18 years.

Obsolescence also has implications for the theoretical reserve. Regulatory reserves for digital ESS are currently only 35.6 percent (Table 1). Those reserves are inconsistent with economic depreciation. For consistency, the (appropriately-discounted) future capital services of those machines would have to be worth 1.8 times as much as the past services that have already been provided.[21] That view of past versus future values is not reasonable, given the expected rapid obsolescence of ESS switches in the future (in addition to continuing price declines, as discussed above). The theoretical reserves in Table 1 would be consistent with economic depreciation if the future value of capital services were worth 1.5 times as much as past capital services. We believe that this estimate of theoretical reserves is conservatively low. The current generation of ESS machines is now well into the latter phases of its life cycle. We believe that the value of future capital services from digital ESS is likely to be worth considerably less than the value of past capital services.

V. Comparison with the Depreciation Practices in Other, Related Businesses

In this section, we compare regulatory depreciation rates to depreciation rates of firms in similar businesses. We observe that LECs are required to depreciate their plant much more slowly than other firms. Indeed:

> *Regulatory depreciation rates are truly anomalous. They embody a view of plant valuation that is wholly inconsistent with practices outside the regulated telecommunications industry.*

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[21] The value 1.8 is calculated as (1 - 0.356)/0.356. In this comparison, future capital services (FCS) should be evaluated as a discounted present value on the date of the theoretical reserve (December 31, 1996). Past capital services should be evaluated as the discounted present value of total capital services on the date that the plant was put in service less FCS.

The general disparity between regulatory depreciation and depreciation of unregulated firms has been documented elsewhere.[22] In this paper, we focus on the disparity between LEC depreciation rates and those of four major LEC competitors: MFS, TCI, AT&T, and MCI. Comparison with these firms is especially interesting, since they are major players and use plant that is in many cases identical, or at least similar, to LECs'. In addition, these firms are frequent interveners in LEC regulatory proceedings. Some or all of these firms may offer advice to the Commission on LEC capital recovery. If so, the Commission may find it interesting to contrast what the firms recommend for LECs versus how they handle depreciation for themselves.

Table 3 below shows depreciation relative to property plant and equipment for these four firms and for LECs, on average. For each firm, depreciation expense is related to the average of gross plant at the beginning and end of the year.

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22 *See* Adrian J. Poitras and Lawrence K. Vanston, "Implications of Technology Change and Competition on the Local Exchange Carriers," USTA Reply Comments 3/1/96, Attachment D (Technology Futures, Inc.).

Table 3
Comparison of Depreciation Rates

	PPE 12/31/95 ($M) (1)	PPE 12/31/94 ($M) (2)	Depreciation Expense[a] 1995 ($M) (3)	Depreciation Rate 1995 (3)/([(1)+(2)]/2) (%) (4)
AT&T Communications [b]	$24,530	$23,122	$2,673	11.2%
MCI [c]	14,243	12,218	1,308	9.9
MFS	1,316	787	100	9.5
TCI Communications Inc.	10,152	8,578	848	9.1
Average:				9.9
LECs				7.3

[a] Excludes amortization of intangible assets.
[b] Reflects 12/94 and 12/93; 12/95 not reported in most recent FCC *Statistics of Communications Common Carriers.*
[c] There was also a $520 million asset write-down in 1995.

Source: AT&T: FCC *Statistics of Communications Common Carriers* (1994/ 1995 edition). MCI, MFS and TCI: Form 10-Ks, 12/31/95, submitted to the Securities and Exchange Commission.

A. MFS

MFS is one of the largest competing local exchange carriers. It provides local telephone service, the same as incumbent LECs. It uses the same general types of plant as LECs; primarily cable, circuit equipment and switching equipment. However, MFS's plant is more heavily weighted toward fiber-optic cable. Fiber is generally depreciated more slowly than circuit equipment, switching equipment or copper cable. Thus, to reflect declines in economic value, MFS's depreciation would expectedly be slower than LEC *economic* depreciation.

In reality, MFS depreciates plant 30 percent faster than the average LEC. MFS apparently believes that its reported depreciation rate provides stockholders with a fair view of the value of the company's plant. If MFS is correct, then LEC depreciation falls far short of reflecting declines in economic value.[23]

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[23] The comparison is even worse when one considers that LECs have substantial plant that is already, or is rapidly becoming, obsolete. Such plant needs to be depreciated more rapidly in the future than MFS's plant.

The above comparison applies to annual depreciation expense. Since annual depreciation expense by LECs appears inadequate, we conclude that the capital-recovery problem is not getting better. On the contrary, the already serious problem appears to be getting worse every year.

B. TCI

TCI is the nation's largest provider of cable television services. It uses the same general categories of plant as LECs; primarily cable, circuit equipment and switching equipment. However, TCI's plant has a substantially different mix than does the LECs'. In particular, cable is a larger component of TCI's plant; switching equipment is a much smaller component.

Cable is generally depreciated more slowly than either circuit equipment or switching equipment. Thus, to reflect declines in economic value, TCI's depreciation would expectedly be slower than LEC *economic* depreciation.

In reality, however, TCI depreciates plant 25 percent faster than LECs. TCI apparently believes that its reported depreciation rates provides stockholders with a fair view of the value of the company's plant. If TCI is correct, LEC depreciation is far too slow to reflect declines in economic value.

C. AT&T and MCI

AT&T and MCI also use the same general types of plant as LECs. In fact, the fiber-optic cable and digital switching are essentially identical. However, AT&T and MCI's mix of plant is weighted less heavily toward cable and more heavily toward switching equipment and circuit equipment. Since switching and circuit equipment are generally depreciated more rapidly than cable and wire, it is not surprising that AT&T and MCI have higher depreciation rates than LECs. However, the difference is surprisingly large. AT&T depreciates plant 53 percent faster than LECs; MCI depreciates plant 36 percent faster than LECs. Indeed, both the AT&T rate and the MCI rate exceed what LECs are allowed for depreciation of *either* digital ESS or circuit equipment — let alone cable.

AT&T's depreciation rates in Table 2 are those reported to regulators. Hence, AT&T has represented to regulators that those rates are appropriate. Furthermore, AT&T now uses *accelerated* depreciation in its financial reporting for much of its plant. Apparently, AT&T believes that straight-line depreciation is too slow to reflect declines in economic values. MCI apparently believes that its reported depreciation rates provide stockholders with a fair view of the value of the company's plant. If AT&T and MCI are right, then LEC depreciation is too slow to reflect declines in economic value.

VI. Hatfield Model and FCC Proxy Costs

In this section, we consider evidence relating to the Hatfield Model (HM) and the FCC proxy-cost estimates. Both imply an extremely serious capital-recovery problem — much more serious than that claimed by the LECs.

We have argued elsewhere that the HM and the FCC proxies may seriously underestimate LEC costs — even on a forward-looking incremental basis.[24] We remain firm in that view. Nevertheless, we believe that regulators should be consistent — however they estimate LEC costs. If regulators base interconnection pricing on the FCC proxies or the Hatfield model, they implicitly acknowledge that regulatory depreciation in the past has been far from adequate. They should use that same view of the world in setting LEC depreciation rates. It is patently unfair for regulators:

1. To set interconnection rates — contrary to LEC interests — based on one view of the world; and
2. To decline to address the capital recovery problem — also contrary to LEC interests — based on a contradictory view of the world.

Furthermore, such self-contradictory policymaking is almost certain to skew competition, misallocate resources, and generate economic waste.

A. Hatfield Model

The HM provides estimates of LEC costs. The HM calculations are based on estimates of investment, an annualizing factor for investment, and estimates of operating expenses. For our purposes here, we focus on the estimates of investment. In particular, we are interested in the investment that the HM calculates is required (in its greenfield model) to provide the current level

[24] Strategic Policy Research, *A New Set of "Top-Down" Incremental Cost Measures,* Bethesda, Maryland, November 17, 1996.

of LEC services. That estimate corresponds (subject to the limitations of the HM analysis[25]) to the economic value of LEC plant.

We ran HM 2.2.2 for the BOCs in all 47 states and the District of Columbia; for Southern New England Telephone in Connecticut; and for GTE in California, Florida, Hawaii and Texas using the default data and settings in the HM as distributed. We then accumulated data from each run to calculate the total investment that the HM calculates is required for the BOCs and GTE to replicate their current network capacities. We also tabulated the information on telephone plant in service (TPIS) provided by the HM and originally from the ARMIS files for each LEC.

Table 4 below shows the total capital costs for the 53 companies/jurisdictions combined. Data are shown for each of 11 categories of plant.

[25] Our views of these limitations are discussed in the following two reports: Ross M. Richardson and Harry M. Shooshan III, *Comments on Hatfield Study,* prepared on behalf of BellSouth for submission before the Federal Communications Commission, *In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996*, CC Docket No. 96-98, *Reply Comments*, filed May 30, 1996; and John Haring, Calvin S. Monson and Jeffrey H. Rohlfs, *Comments on FCC's Industry Demand and Supply Simulation Model*, prepared on behalf of BellSouth for submission before the Federal Communications Commission, *In the Matter of Implementation of the Pay Telephone Reclassification and Compensation Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-128, *Supplemental Comments,* filed July 8, 1996.

Table 4 Plant Investment Used in HM 2.2.2 with Parameters Set at Default Value (53 Companies/Jurisdictions)		
Category	**Gross Investment ($) (1)**	**Devalued Investment ($) (2)**
General Support	$7,307,402,068	$3,527,116,450
Distribution	$44,592,169,356	$27,857,769,384
Concentrator	$12,766,243,714	$6,734,520,657
Feeder	$19,091,403,745	$11,926,845,687
End office Switching	$19,921,652,758	$11,767,679,095
Signaling	$676,849,894	$387,052,984
Dedicated Transport	$5,154,596,493	$3,178,550,913
Common Transport	$447,178,350	$275,749,839
Tandem Switching	$772,957,498	$475,679,648
Operator	$573,559,806	$286,492,038
Public Telephone	$1,752,413,101	$901,175,049
Total	$113,056,426,783	$67,318,631,745

As Table 4 shows, total investment in the HM is $113 billion. This reflects (subject to the limitations of the HM) the economic value of plant for a brand new network.

The table shows the original investment estimated by the model for each of these 11 categories. These estimates correspond to what the economic value of embedded LEC plant *would be* if the plant were all brand new. In reality, embedded plant is not brand new. Consequently, the economic value of embedded plant implied by the HM 2.2.2 is somewhat lower than the amount of investment.

The HM uses a complicated procedure to estimate capital costs. That procedure is shown in the spreadsheet containing the outputs of HM. Part of the procedure involves devaluing original investment to reflect the value of a network with plant of mixed ages. The devaluation is apparently based on an approximation of the age distribution of embedded plant. The estimates of devalued investment — after this procedure is carried out — correspond to the economic values of LEC plant — given the actual age distribution of plant.

The aggregate ratio of devalued investment to original cost over all categories of plant is 60 percent. The devalued estimate of investment reflects (subject to the limitations of the HM) the economic value embedded plant, given its actual age distribution. That value amounts to $67 billion.

This amount can be compared to telephone plant in service (gross plant) of $235 billion.[26] The economic value of telephone plant implied by the HM is 29 percent of gross plant. This corresponds to a theoretical reserve of 71 percent. The implied theoretical reserve is 1.3 times that estimated by the LECs and shown in Table 1. For these companies, a theoretical reserve of 71 percent would imply a depreciation shortfall of over $60 billion. Put another way, the HM implied estimates of economic value would need to increase by over 60 percent in order to be consistent with the LECs' estimates of the theoretical reserve. The implied HM estimates would need to increase by almost 90 percent to be consistent with the view that there is no capital recovery problem; *i.e.*, that regulatory book values correspond approximately to economic values. All in all, the HM implies a much more serious capital-recovery problem than claimed by the LECs.

B. <u>FCC Proxy Costs</u>

The FCC proxy costs for loops are, on average, very close to those implied by the HM. The average FCC proxy (weighted by loops) is $14.32 per month;[27] while the HM average (as of March 29, 1996) was $13.84.[28] The difference is 3 percent.

The FCC proxy for switching costs is a range of $0.002 to $0.004 per minute for end-office switching. The HM estimate is $0.0018 per minute for end-office switching. Thus, the lower end of the FCC proxy range is close to the HM estimate.

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26 We note that the FCC reports that year end 1995 TPIS for the entire industry is $266 billion. The difference between this total and the $235 billion in the table is due to the fact that the HM considers only the major LEC operations in the United States. It misses all the smaller companies and GTE in many jurisdictions. The capital missed includes major firms like Sprint's local exchange operations and all LEC operations in Alaska, Puerto Rico, Guam, *etc.*

27 This average is weighted by access lines.

28 Hatfield Associates, Inc., *The Cost of Basic Network Elements: Theory, Modeling and Policy Implications,* prepared for MCI Telecommunications Corporation, March 29, 1996.

The FCC proxies for switching ports is also a range: \$1.10 to \$2.00 per month. The corresponding HM estimate is \$1.02 per month. Thus, as before, the lower end of the FCC proxy range is close the HM estimate.

All in all, the FCC proxies for loop costs are close to the HM estimates; the lower end of the FCC proxies for switching costs are also close to the HM estimates. We can reasonably infer that the lower end of the FCC proxy ranges is consistent with economic values of capital similar to those in the HM. Thus, the lower end of the FCC proxies implies an extremely serious capital-recovery problem — on the order of \$60 billion.

If one uses the upper end of the FCC proxy range for switching costs, the implied capital recovery problem is smaller. However, *total* costs (loops plus switching) are only slightly higher at the upper end of the proxy range than at the lower end. We previously observed that the economic values implied by HM would need to increase by over 60 percent to be consistent with the LEC estimates of the theoretical reserve. Thus, it appears that the FCC proxy costs — even at the upper end of the ranges — imply a more serious capital recovery problem than claimed by the LECs.

VII. Norsworthy Analysis

In the LEC price-cap docket, AT&T filed a statement by J.R. Norsworthy.[29] The statement argued for *(inter alia)* a large input-price differential. Norsworthy used a quality-adjusted index of capital input prices in a quantitative analysis of LEC productivity. The index is based on an earlier study by Norsworthy and Jang. We do not espouse the Norsworthy/Jang estimates. They do, however, reflect *AT&T's* views on capital input prices.

Norsworthy's capital-price index begins at 100 in 1985 and declines to 65.1 by 1994. The average rate of decline is 4.77 percent per year. This rate is expressed in nominal terms. The real rate of decline, adjusted for inflation, is significantly greater than 4.77 percent per year.

The Norsworthy analysis implies that the economic value of LEC plant declines by 4.77 percent per year solely to reflect declines in quality-adjusted equipment prices. This decline is in addition to economic depreciation that reflects obsolescence, the possibility of stranded plant, and increasing maintenance expenses as plant gets older. The implication is that for any economic life,

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[29] *Analysis of TFP Methods for Measuring the X-Factor of the Local Exchange Carriers' Interstate Access Services,* Statement of Dr. John R. Norsworthy, Appendix A, 1995.

economic depreciation is much faster than straight-line depreciation in the early years. Consequently, the economic depreciation reserve would be greater than the reserve under straight-line depreciation — no matter what the mix of plant vintages.

The LEC estimates of the theoretical reserve in Table 1 are based on straight-line depreciation. The Norsworthy analysis would imply a much higher theoretical reserve than claimed by the LECs — even if the same economic lives were used.

VIII. Conclusions

For decades, state and federal regulators have required LECs to depreciate their plant slowly. Regulators chose low depreciation rates in order to reduce cost-based prices in the short term. As a result, there is now a large "depreciation shortfall"; *i.e.*, the disparity between the regulatory book value of plant and its economic value in use. A change in regulatory policy is essential if the new Communications Act is to be effectively implemented.

Reserve-shortfall estimates based on accounting methodology were developed by the price-cap LECs that are fully subject to depreciation regulation. The LECs estimate that depreciation reserves should be 54.0 percent instead of the actual value of 47.0 percent; the estimated shortfall is 7.0 percent of gross plant or $18 billion.

The LECs' conservative estimates, which are based on accounting methods, do not fully reflect declines in economic values of plant. These estimates constitute a conservative view of the capital-recovery problem. The actual problem, taking declines in economic values fully into account, is almost surely worse (and may be considerably worse) than implied by the LECs' conservative estimates.

The depreciation shortfall is greatest for copper cable. Technological improvements in fiber-optic systems are continually driving down the economic value of copper plant. Fiber-optics is already cost-effective for feeder loops. In that sense, copper feeder loops are already obsolete. Fiber technology will ultimately obsolete copper distribution plant, as well.

The depreciation shortfall for digital switching plant is also substantial. Switch prices are declining at a significant rate. In addition, current switches are becoming obsolete, in part as a result of the growth of computer networking; *e.g.*, on the Internet. These factors drive down the economic value of switching investment.